

SECTION 16

N 72-29317

LEWIS RESEARCH CENTER EARTH RESOURCES PROGRAM

by

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INTRODUCTION

In our Earth Resources program at Lewis Research Center we are attempting to bring NASA technical capabilities to bear on regional problems that would benefit from such attention. We have, quite frankly, made it a point to select problems existing in our region from among those which we believe are possible to do, and we've added the requirement that solution of the problem will directly make many people in the area happy that the NASA had the technological capability to provide the solution, while at the same time making very few of our local citizens mad at us. Our goals thus include visibly demonstrating NASA technical capability to the general community along with conducting the scientific effort itself. The areas of effort (fig. 1) because of our location, seemed most appropriately to be the following: Monitoring and rapid evaluation of water quality, determination of ice-type and ice coverage distribution to aid operations in a possible extension of the Great Lakes Ice Navigation and Shipping Season and preliminary efforts to monitor the spread of crop viruses and the extent of damage to strip-mined areas as well as the success of efforts to rehabilitate such areas for agriculture. These problem areas are listed in figure 1.

DESCRIPTION OF THE STUDIES

Water Quality

The first of these, the study of water quality, is being done in two parts. The first is in cooperation with the Environmental Protection Agency and their Headquarters Office of Research and Monitoring. Under the Office of Research and Monitoring, as you might guess, there is an Office of Research and an Office of Monitoring. At present they are not sure under whose management this effort should come in their Headquarters Office, but they agree that the work should be done. The local EPA people that we deal with in the Lake Erie Basin Office in Cleveland, and the Measurements Laboratory people in Cincinnati are very enthusiastic, as are the EPA people in the 5th District Office in Chicago. What we

have done is to obtain several IRLS-Nimbus IV data collection packages and we have deployed one on the Great Miami River near Cincinnati, Ohio (fig. 2).

The IRLS, or Interrogation, Recording and Location System data collection package is inside this trailer near the Miami River. This package can be interrogated by Nimbus IV several times a day. It is provided with the capability of transmitting seven analog channels of data of which two are housekeeping voltages and five are input data. The parameters we are reading in the Miami River are dissolved oxygen, conductivity, temperature, pH, and a standard voltage. These are simultaneously being sent by telephone to EPA offices in Cincinnati. The data that Nimbus receives is recorded, then subsequently dumped to a ground station, sent by hard-line to Goddard, and Goddard sends it to Lewis by mail. The EPA is delighted with this installation and we're presently discussing with them the deployment of another IRLS package at the outflow from the Eastlake Power Plant in Lake Erie, as well as the possible use of 20 ERTS DCS packages to aid them in their essential monitoring duties since they are extremely short of people to monitor the areas in this district for which they have responsibility. With the present antenna, we're getting two to six responses for every twelve interrogations, so we designed an 11dB gain antenna for these fixed location applications (fig. 3), and now we get >nine responses for every twelve interrogations.

We plan to continue using the conical helix shown in figure 2 for moving applications, however, to maintain axi-symmetry. In a cooperative effort with the Canada Centre for Inland Waters in the IFYGL studies on Lake Ontario, we are planning to use the locating feature of the IRLS to determine surface currents on the lake by placing a package on a high water drag buoy which CCIW is designing and building. At the same time, we are designing circuitry to integrate surface winds in time and store the integrated values for interrogation. CCIW will have two ships on the lake 24 hours a day to care for the buoy and package.

In another cooperative program with the Canada Centre we have overflowed their research vessel, the C.S.S. Limnos (fig. 4), with a scanning spectrometer while the Limnos has made chemical and organic particle density measurements at five depths, at each of six stations in Lake Erie.

At each station shown in figure 5, the Limnos makes a measurement 1 meter below the surface, 6 meters below the surface, one just above the thermocline, one just below, in the hypolimnion, and one on the bottom. As soon as CCIW can reduce the data, we will attempt to see if the measurements of organic material at depth can be correlated with the surface density values, thereby to obtain a correlation for the entire column

of water with the overflight spectral readings. We have similarly overflown their M.S. Martin Karlsen (fig. 6), which makes measurements at 50 points in Lake Erie shown in figure 7. The Canadians have formally agreed to work together with these data as well. On one of our flights over the Cleveland Sewage Treatment Plant, we caught a color IR of a serious accidental spill of millions of gallons of raw sewage (fig. 8). When we looked more closely, there was a man in a boat sailing right through it (fig. 9). We have some really tough sailors in Cleveland.

Ice Type Distribution Monitoring

Our second area of interest is that of ice type evaluation and monitoring (fig. 10). This program grew out of discussions we had early in the year with Captain E. F. Walsh, Chief of Operations, 9th Coast Guard District. He agreed that if his Ice Information Center could get really good information on the kind and distribution of ice coverage on the Lakes, it would make operating into the ice season much easier. At the present time, shipping on the lakes moves for about 8 months. From the latter part of December to the middle or latter part of April, most shipping ceases due to ice covering the lakes, channels, and harbors. Since a total of 250×10^6 tons of cargo are shipped on the lakes (20 percent of total U.S.), the value of lengthening the shipping season has become apparent to others and some months ago, Congress passed a bill authorizing a group of Federal Agencies led by the U. S. Army Corps of Engineers and the Coast Guard to perform a 3-year demonstration to determine the feasibility of extension of the shipping season. Last year, with Captain Walsh's cooperation, we had already made flights to look at the ice coverage and the variation in ice types. Figure 11 is a photograph of ice in a channel. In figure 12 is shown the pattern seen when ice sheets begin to come together. In figure 13 can be seen a photograph of ice with a large opening and the results of automatic processing programs put together to determine the area of such openings in the ice. In figure 14 we see broken-up ice, starting to refreeze. Notice how definite the patterns are. It occurred to us that the information determining lake ice type might often be there, but that much of it would be in patterns. Questions such as: How big are the pieces? Are they getting bigger or smaller? How many holes? How big are the holes? appeared to be the type that would require answering. So we developed some programs to permit us to count objects. We felt that the counting of objects would be valuable in other applications as well as in the ice program and this will be discussed later where it does apply.

In figure 15 the left figure is a pictorial representation of an object; the right figure shows how a computer would view the object after it had been "seen" by some sensor and suitably digitized.

In the computer study of the object, the array is scanned one line at a time (top to bottom) and one element at a time (left to right). An algorithm has been developed in which scale-independent geometric features (heads = H, tails = T, splits = S, and joins = J) are recognized as the scanning proceeds and the sums are recorded. Actually at any one time only two lines need to be known by the computer: the line being scanned and the previously scanned line. Thus the entire two-dimensional array need not be stored at one time -- a space-saving feature.

Note that the first relation ($\Sigma H + \Sigma S - \Sigma T - \Sigma J = 0$) provides a way of telling when an object has been completely scanned -- the expression equals 0 when the object is complete. As each object is completed, the object counter is incremented. Although only a single object is shown in the figure, the computer can keep track of multiplicity of complicated objects as they unfold during the scanning (even spirals, objects within objects, etc.)

Notice that once the H T S J sums have been obtained for an object, the second relation can be used to tell how many holes each object has. This, along with the object count, gives two scale-independent pieces of information about an image.

Since the algorithm for recognizing H T S and J's considers in turn each element making up an object, we can concurrently keep track of any property of the object which can be calculated one element at a time. For example:

area = A
perimeter = P
center of mass
inertia tensor

From these, useful scale-independent parameters such as P/\sqrt{A} ('jaggedness' parameter) can also be constructed.

Figure 15 shows an object consisting of either x or no-x elements ("black and white"). If objects are recorded in different shades of grey or in different colors, or if there are several kinds of objects (as is the case for most real images), the problem is handled by simultaneously performing the above analysis for each shade, color, or type of object. Each additional kind of object requires additional storage for keeping track of the sums.

Algorithms have been developed for other interesting tricks, such as "counting" composite objects (objects consisting of the union of two or more types of distinguishable objects) and detecting which objects

border selected sets of other objects.

As work progresses we hope to branch from the "counting" stage of analysis just described to more sophisticated techniques of pattern recognition.

In figure 16 is shown the organization of the Federal Ice Board mentioned earlier. At the formal request of Major General Ernest R. Graves, the Division Engineer of the U. S. Army Corps to the NASA Administrator's Office, I was named to fill the NASA slot on the board in December 1971. We are hoping that Lewis' effort to fly over and make remote images together with ground truth measurements made for us by the Coast Guard, as well as additional ground truth provided by the Lake Survey Center, will result in operational frequency ice type and coverage maps. These will be used by the Coast Guard operations to deploy optimally their small fleet of ice-breakers which have been added for the season extension program. To provide for the problem of cloud cover periods when visible and thermal wavelength band images may be useless, we are planning for Houston P3 16.5 gigahertz SLAR flights in February 1972, as well as an Ames Convair 990 flight in March 1972, using the Goddard 19.1 gigahertz microwave passive scanner. The final goal will be to provide upgraded ice-information to the Coast Guard which can be used, not only in the demonstration, but beyond, during extended shipping seasons. Additional information from satellites will be provided to determine the value of such synoptic views, especially those from ERTS next winter.

Additional Regional Efforts

The third area of effort I'd like to discuss today is shown in figure 17 and is made up of two cooperative efforts with the Ohio Agricultural Research and Development Center. The first is one in which we have attempted to aid USDA entomologists stationed at OARDC in tracking the spread in corn of Maize Dwarf Mosaic Virus of a number of varieties while they keep track of the population distribution of the insects spreading the disease. Toler of Texas A & M has done a similar optical study of St. Augustine Decline Virus with that grass as the model host. In figure 18 we see the test plots of corn being subjected to the disease. In figure 19 we show a sample of a plant infected with MDMV. A lab plot (fig. 20) of optical properties of healthy corn compared with corn suffering from the virus indicates that it is transmission that is increasing in the infected leaves. A lab composite indicates that this should result in increased reflectance at 5600 Å and field spectra of diseased plants do indeed exhibit this increase (fig. 21).

The Ohio Agricultural Research and Development Center at Wooster, Ohio, is an outstanding agricultural scientific group, and they've been

working diligently on a test strip-mined area in Noble County, Ohio (fig. 22) for some years to determine what should and can be done about the devastation to the countryside caused by the strip-mining activities in Ohio. Discussions we have had with Dr. R. Davis, Assistant Director of OARDC and with Dr. Burley Schmidt, Head of the Department of Agronomy there, have resulted in a cooperative effort at their test site. Our present plan is for Dr. Paul Sutton, the agronomist in charge of the test site and his crew to provide us with soil and sample classifications which we are to try to identify remotely. If we can identify the samples of interest by remote sensing, we will have the beginnings of a system to determine rapidly the damage being done. Figure 23 is a photograph (near IR) of the test area. Figure 24 shows how clearly the stripped areas stand out against the remaining vegetation. Dr. Sutton has provided us with eight samples (fig. 25) which are of interest, and the color photo shows how distinguishable these soil types are. In figure 26 lab spectra show that the soil types are detectable, and our cooperative effort continues to see if the extent of these various soil types can be determined for the test plot. Since a major purpose of the effort is the rehabilitation of such areas for agriculture, various types of agricultural efforts have been made. For example, orchards (fig. 27) have been planted in the ruined areas. Our efforts are involved here in determining the success of such efforts at agricultural rehabilitation, hopefully in a rapid and automatic way. For evaluating the success of orchard plantings, here we have developed (fig. 28) our object counting programs to include the ability to determine the state of the orchard, tree by tree, automatically permitting rapid large area evaluations. It should be pointed out here that strip-mining in Ohio is a \$500 million a year industry and everyone, including the mining industry, would like a proper and realistic cost of rehabilitation to be determined. At present, an acre brings in \$25,000 from coal but less than \$200 per acre in fines. Since such efforts could never be halted, it is necessary to make proper estimates of damages and costs so that increased charges be made when necessary, and even as important, made smaller -- even zero -- when appropriate, say when soil easy to rehabilitate is turned up. The goal of our cooperative effort with OARDC is to provide some of the capability to permit this eventually on an operational basis to assist everyone concerned. The mining industry, the agricultural industry, as well as the state and its people, will all benefit from the development of such a capability.

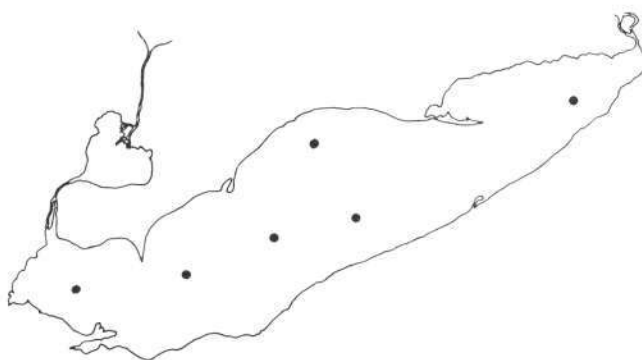
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Figure 3. - High gain antenna for fixed location IRLS packages.



Figure 4. - Canadian steamship LIMNOS making in the water measurements in Lake Erie.



CS-61278

Figure 5. - Lake Erie organic particle measurement stations of the C. S. S. LIMNOS.

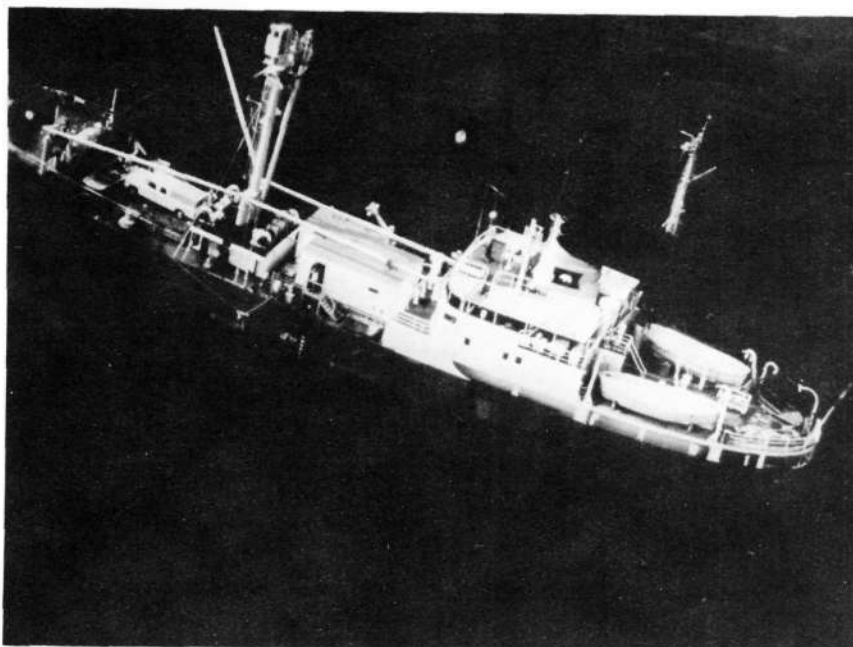
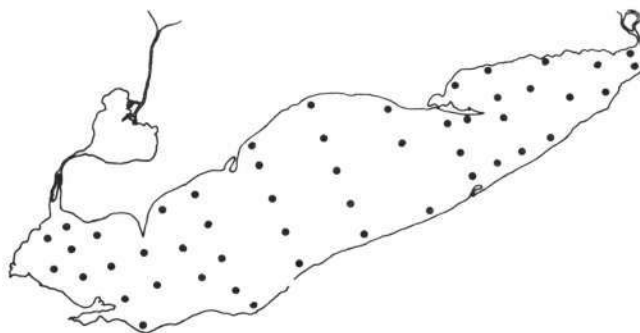


Figure 6. - Canadian motor vessel Martin Karlsen making in the water measurements in Lake Erie.



CS-61277

Figure 7. - Lake Erie measurement stations for the C.M.V. Martin Karlsen.



Figure 8. - Accidental sewage spill at Cleveland Sewage Treatment Plant (near IR).

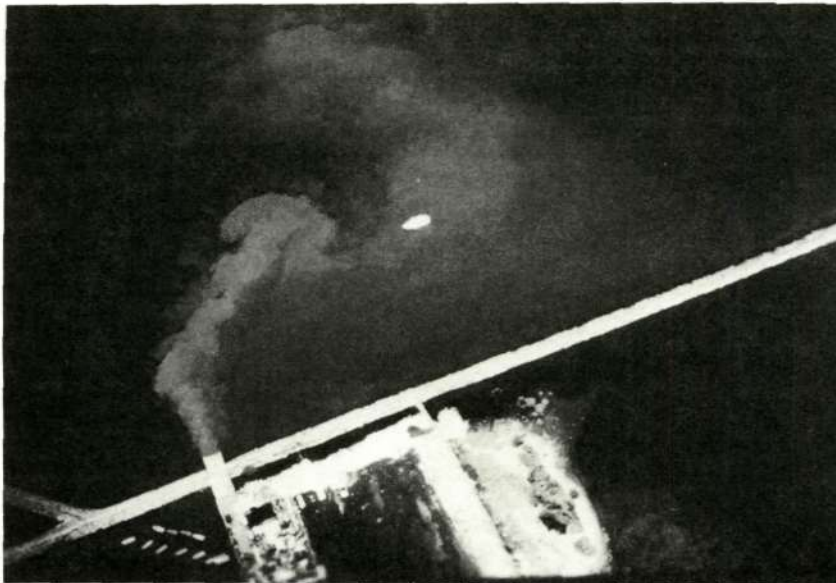


Figure 9. - Closeup view of raw sewage spill at Cleveland Sewage Treatment Plant (near IR).

160-75-60: MIDWEST/GREAT LAKES APPLICATIONS OF
EARTH OBSERVATIONS SATELLITES

2. HYDROLOGY, LIMNOLOGY - HL-1

GREAT LAKES ICE EVALUATION & MONITORING

CS-61289

Figure 10. - Lewis Research Center Ice Monitoring Program.



Figure 11. - Channel ice seen from 1000 foot altitude.



Figure 12. - Ice sheets beginning to overlap as seen from 1000 foot altitude.



OBJECT TYPE *

5(1)

2(2)

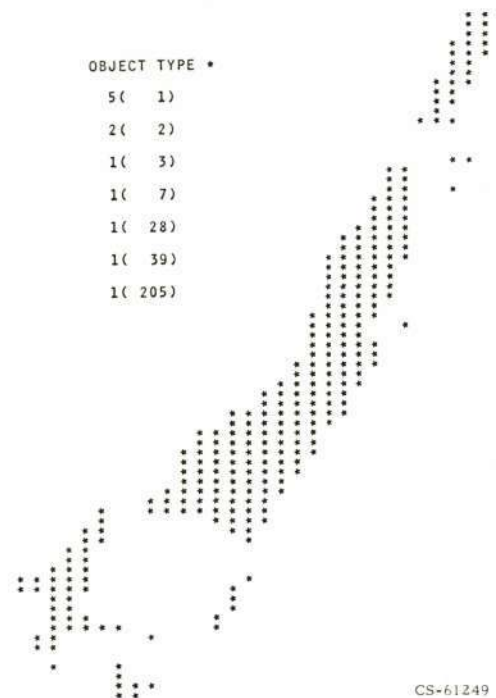
1(3)

1(7)

1(28)

1(39)

1(205)



CS-61249

Figure 13. - Photo showing large opening in ice and results of automatic processing of the photo.

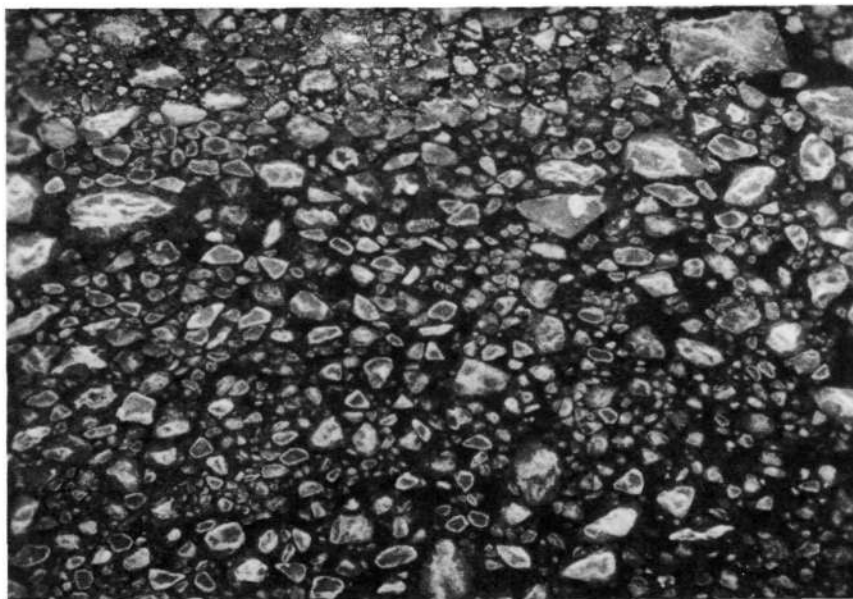
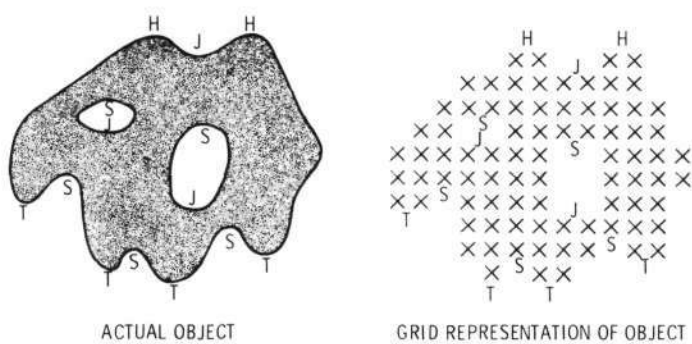


Figure 14. - Patterns of broken ice starting to refreeze seen from about 1000 foot altitude.



ACTUAL OBJECT

GRID REPRESENTATION OF OBJECT

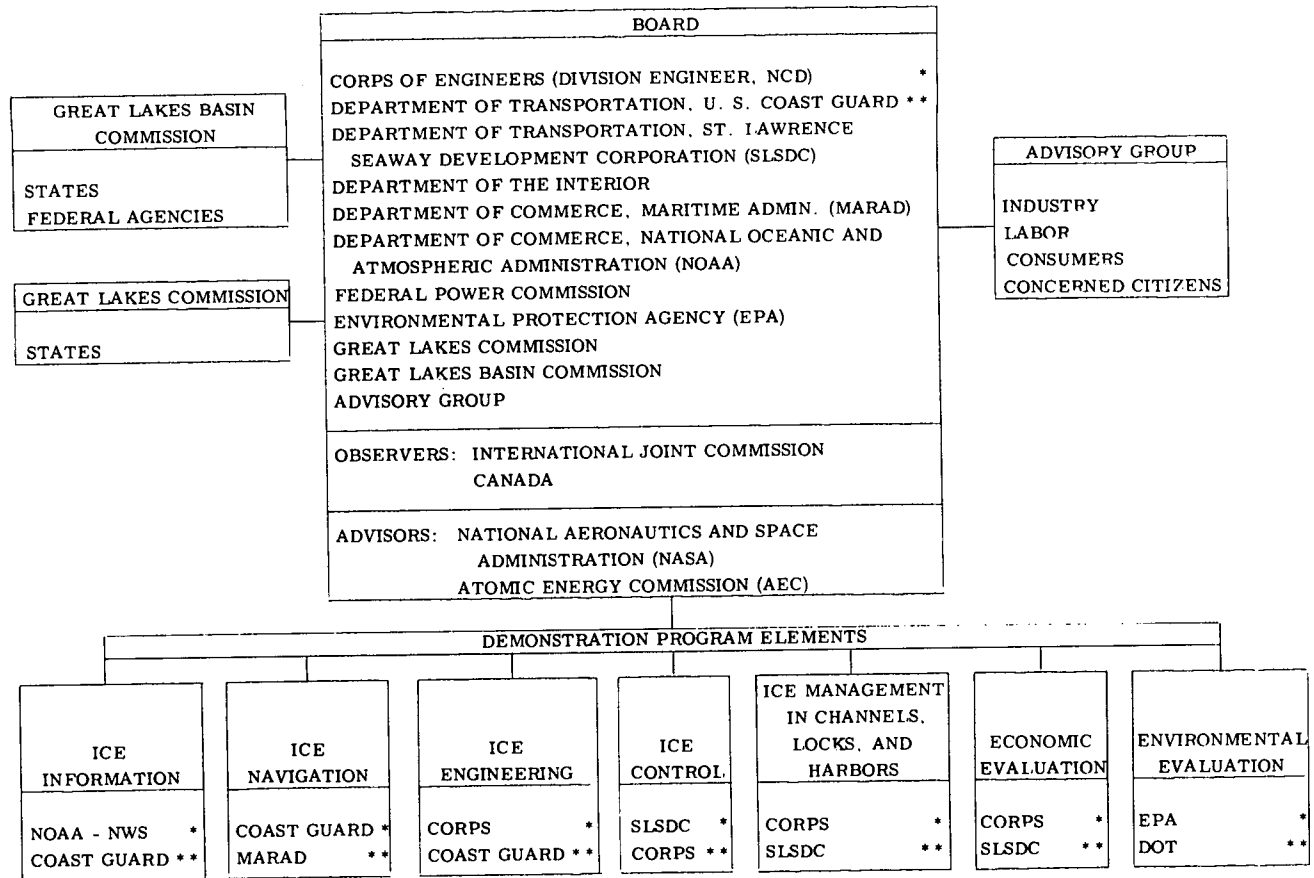
FOR ANY OBJECT:

$$\sum H + \sum S - \sum T - \sum J = 0$$

$$\text{NUMBER OF HOLES} = \frac{(\sum S + \sum J - \sum H - \sum T + 2)}{2} \quad \text{CS-61790}$$

Figure 15. - Example of computer object counting.

ORGANIZATION FOR GREAT LAKES - ST. LAWRENCE SEAWAY
NAVIGATION SEASON EXTENSION DEMONSTRATION PROGRAM



* Lead Agency (Chairman of Work Group)
** Vice-Chairman of Work Group

CS-61279

Figure 16. - Organization of the Federal Ice Board.

160-75-60: MIDWEST/GREAT LAKES APPLICATIONS OF
EARTH OBSERVATIONS SATELLITES

3. AGRICULTURE, FORESTRY, & RANGE - AF-2, 4
PRELIMINARY STUDIES OF CROP DISEASE SPREAD
& STRIP-MINED AREA REHABILITATION FOR
AGRICULTURE

CS-61288

Figure 17. - Additional regional studies in Lewis Program.

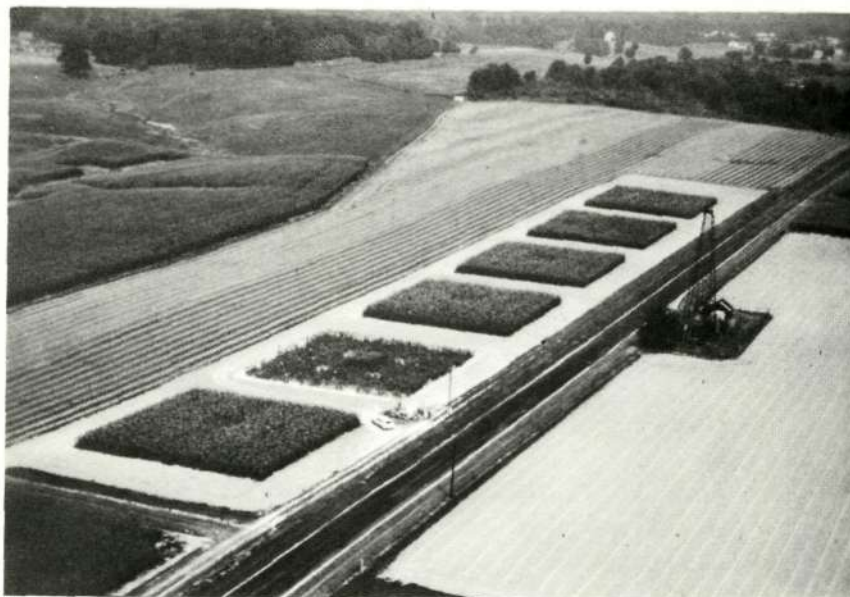


Figure 18. - Aerial photo of test plots of corn at Wooster, Ohio.



Figure 19. - Sample of corn plant infected with Maize Dwarf Mosaic Virus.

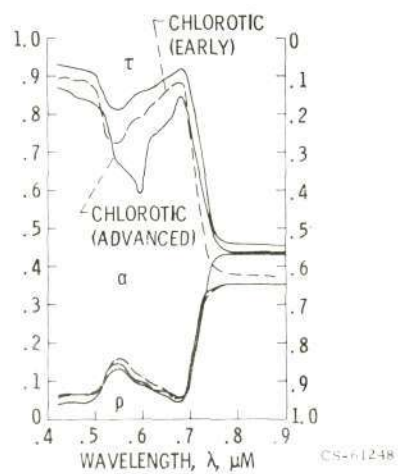


Figure 20. - Optical properties of healthy corn and corn infected with MDMV.

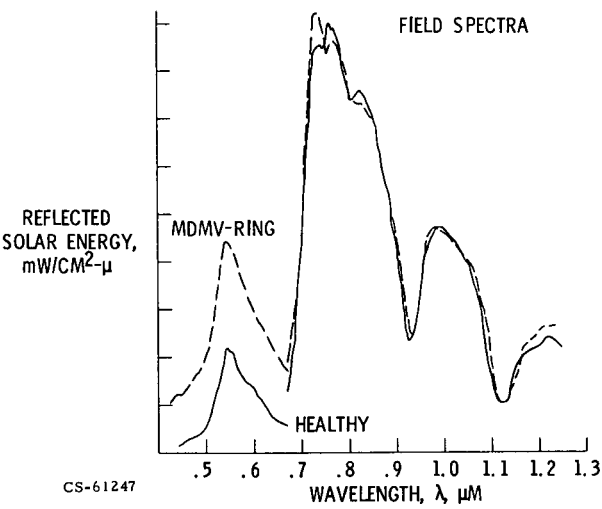


Figure 21. - Field spectra of healthy corn and corn infected with MDMV.

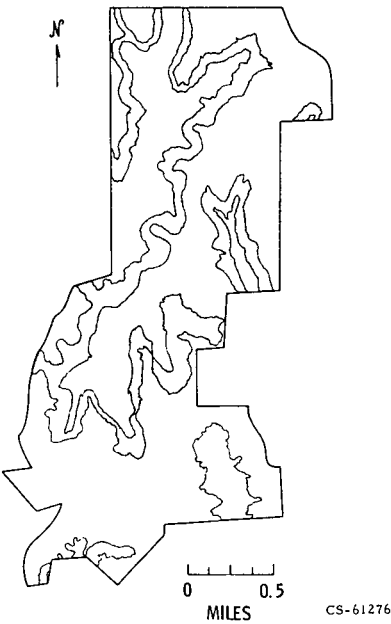


Figure 22. - OARDC test strip mined area in Noble County, Ohio.



Figure 23. - Photograph from 1000 foot altitude of OARDC test strip-mined area in S.E. Ohio.



Figure 24. - Close-up aerial photo (500 foot altitude) of strip mined area in S.E. Ohio.



Figure 25. - Soil samples from test-strip-mined area in S.E. Ohio.

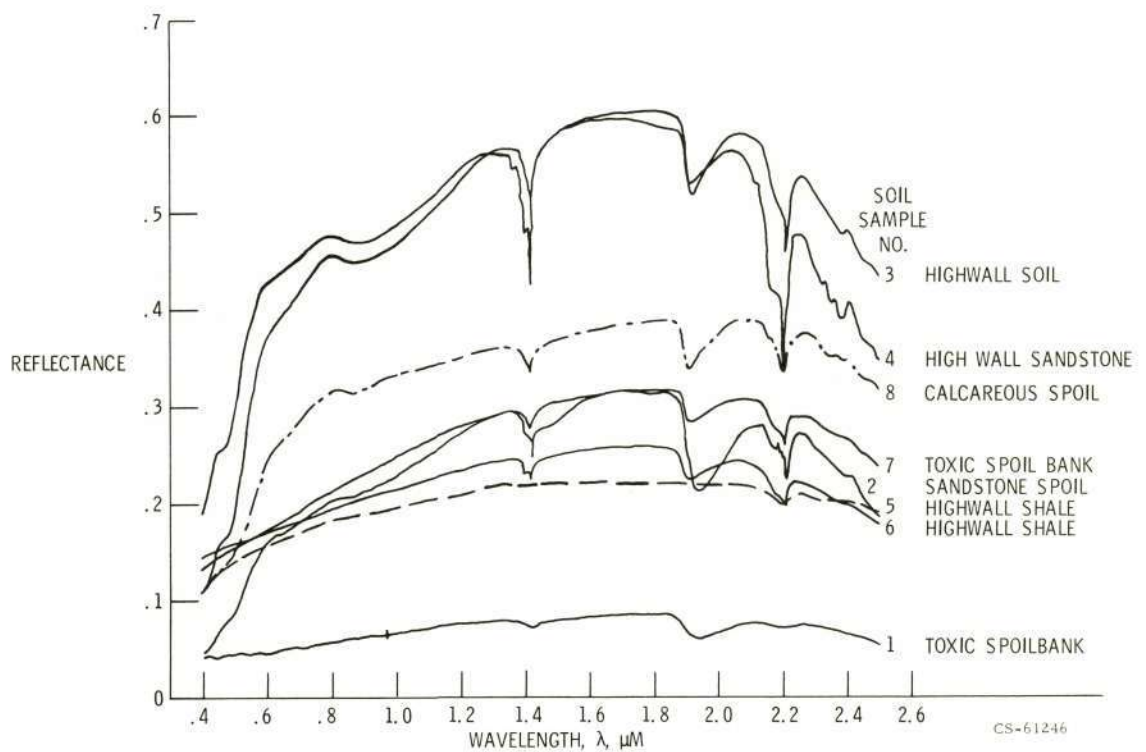


Figure 26. - Laboratory spectra of soil types from test strip mined area in S.E. Ohio.



Figure 27. - Efforts at agricultural rehabilitation of test strip mined area in S.E. Ohio.

**A*	*
AA*AAA	***
AAAAA	**AA*A
AAAAAA	AAAAAA
AA	AA A
AAAA	AA
A AAAA	AAAAA
AAAAA	A*AAAA
A AAAA	AAA**
AAAA	***
A	*
AAA	AA*
AAAAAA	AAAAA
AAAAAA	A***AA
AAAA	A*AA
A AA	A

NO.	SIZE	HOLES	PERIM	* TOT AREA	%	A TOT AREA	%
1	23	0	24	2 4	17.4	1 19	82.6
2	26	0	28	2 7	26.9	1 19	73.1
3	24	1	34	0 0	0.0	1 24	100.0
4	22	0	24	2 7	31.8	1 15	68.2
5	22	0	24	0 0	0.0	1 22	100.0
6	19	0	22	2 5	26.3	3 14	73.7
136				8 23	16.9	8 113	83.1

CS-61245

Figure 28. - Computer object counting technique applied to trees in test orchard.